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Magnetic Energy Morphing, Capacitive Concept for $Ni_{0.3}Zn_{0.4}Ca_{0.3}Fe_2O_4$ Nanoparticles Embedded in Graphene Oxide Matrix, and Studies of Wideband Tunable Microwave Absorption

Chandi Charan Dey, Sukhendu Sadhukhan, Ayan Mitra, Madhumita Dalal, Anirban Shaw, Anna Bajorek, and Pabitra K. Chakrabarti*

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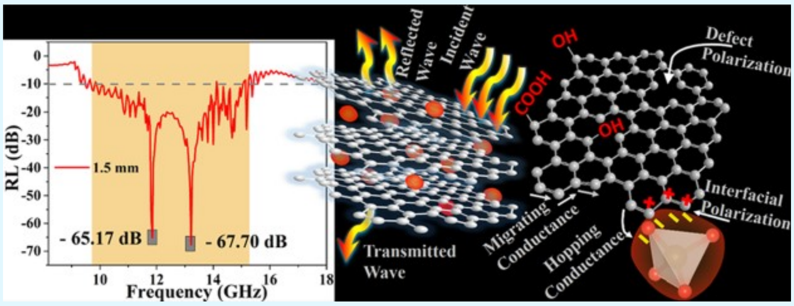

ABSTRACT: Nanoparticles of $Ni_{0.3}Zn_{0.4}Ca_{0.3}Fe_2O_4$ (NZCF) were successfully prepared by the facile wet chemical method coupled with the sonochemical method. These nanoparticles were embedded in a graphene oxide (GO) matrix (NZCFG). Rietveld analyses of X-ray diffraction, transmission electron microscope, scanning electron microscope, and X-ray photoelectron spectroscopy were carried out to extract different relevant information regarding the structure, morphology, and ionic state. A major improvement in saturation magnetization is achieved due to substitution of Ca^{2+} in the ferrite lattice. Interestingly, the observed value of electromagnetic absorption for a sample thickness of 1.5 mm is ∼−67.7 dB at 13.3 GHz, and the corresponding bandwidth is 5.73 GHz. The Cole−Cole plot, the Jonscher power-law fitting, and the Nyquist plot confirm the probability of improved hopping conductance and attractive capacitive behavior in NZCFG. The presence of magnetic energy morphing in combination with a higher attenuation constant, lower skin depth, and various forms of resonance and relaxation makes NZCFG the most suitable for microwave absorption.

KEYWORDS: *graphene oxide, magnetic properties, dielectric losses, energy morphing, Nyquist plot, microwave absorption*

1. INTRODUCTION

With the rapid advancement of civilizations, electromagnetic (EM) functionalized materials and devices have started offering numerous benefits to human activities, such as the use of ultralong waves for maritime communications and navigation; medium-short-range waves for televisions, radios, mobile phones, and medical systems; and centimeter waves for global position systems, military defense system, and satellite communications. The rapid progress of artificial intelligence (AI) has led the future strategy of human lifestyle and way of thinking and has created significant changes in the economic structure.[1,2] The creation of new practical and nano-micro EM architectures continuously refreshes the environment and provides endless vitality to the potential growth of different fields, such as EM wave absorption cum shielding, detection, sensing, imaging, switching and wave filtering, including optics and photovoltaics.[3−6] However, the emitted microwaves from these kinds of devices and/or from other high-frequency circuits have raised serious concerns about risks to human health and the abnormal operation of other sensitive electronic devices.[7−10] The demand for high-potential EM functional materials and devices, especially in low dimensions and nanoscales, has become one of the new scientific focal points. Microwave-absorbing materials may reduce these harmful radiations, but they still face a major challenge when producing high absorption bandwidth with high absorption losses for practical use.

Recently, with the benefits of low density and high reflection loss with a broad adsorption bandwidth, nanomaterials have

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